



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>A61K 9/70, 47/10, 47/18</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 96/20699</b> <b>(43) International Publication Date:</b> <b>11 July 1996 (11.07.96)</b>
<b>(21) International Application Number:</b> <b>PCT/US96/00015</b> <b>(22) International Filing Date:</b> <b>11 January 1996 (11.01.96)</b> <b>(30) Priority Data:</b> <b>08/369,756</b> <b>6 January 1995 (06.01.95)</b> <b>US</b> <b>(71) Applicant (for all designated States except US):</b> <b>NOVEN PHARMACEUTICALS, INC. [US/US]; 11960 Southwest 144th Street, Miami, FL 33186 (US).</b> <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> <b>LI, Chensheng [CN/US]; 14465 Southwest 139th Avenue, Miami, FL 33186 (US).</b> <b>(74) Agents:</b> <b>MELOY, Sybil et al.; Foley &amp; Lardner, Suite 500, 3000 K Street, N.W., Washington, DC 20007-5109 (US).</b>	<b>(81) Designated States:</b> <b>AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AZ, BY, KZ, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</b>  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	
<b>(54) Title:</b> <b>COMPOSITION AND METHODS FOR TRANSDERMAL DELIVERY OF ACID-LABILE DRUGS</b> <b>(57) Abstract</b> <p>A transdermal penetration-enhancing, drug acid-lability reducing composition and related method are described. Specifically, the transdermal composition comprises: (a) a therapeutically effective amount of a pharmacologically active drug which is subject to acid catalyzed degradation; (b) a pharmaceutically acceptable carrier substantially free of a lower alkanol; and (c) a penetration-enhancing amount of a functional derivative of a fatty acid. Such compositions increase the usefulness of transdermal compositions that rely upon an organic acid such as oleic acid penetration enhancer.</p>		

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**Composition and Methods for Transdermal Delivery  
of Acid-Labile Drugs**

5       The present invention relates generally to  
compositions and methods for the transdermal delivery of  
acid-labile drugs. The present invention relates more  
particularly to a drug penetration enhancing transdermal  
composition and related method of use, wherein the  
10       penetration enhancer is a functional derivative of a  
fatty acid that the functional derivative minimizes the  
acid catalyzed degradation of acid-labile drugs.

Transdermal drug delivery systems are effective means  
for introducing drugs into the bloodstream by applying  
them to skin or mucosa. Advantages of transdermal  
15       delivery include convenience, comfort, avoidance of the  
risks associated with enteral and parenteral  
administration, and control over drug absorption. It is  
particularly suitable for treating conditions that are  
systemic in nature, and can be used with any drug that  
20       can pass through the skin or mucosa and that do not  
irritate, or cause an allergic reaction, at the site of  
application. Permeability of a drug through the skin may  
be affected by the stratum corneum, which is  
characterized by dehydrated and keratinized cells, or by  
25       the epidermal layer in the mucosa. The art has  
recognized that the barriers to the transdermal or  
percutaneous delivery of drug through the skin can be  
overcome or reduced by using particular vehicles and  
carriers into which the drug is incorporated, so that the  
30       vehicle or carrier remains at the site of application and  
increases the drug's penetration at that site.

U.S. Patent No. 4,863,970 by Patel (1989) describes  
compositions and methods for improving the penetration of  
pharmaceutically-active agents that are lipophilic or  
35       hydrophilic, including salts thereof. The topical  
compositions of Patel contain a pharmaceutically-active  
agent dissolved in, or admixed with, a penetration-  
enhancing binary mixture of (a) one or more cell-envelope

disordering compounds such as oleic acid, and (b) a lower alkanol (e.g., C2 or C3 lower alcohol). In addition, the formulation can optionally contain inert hydrophilic or hydrophobic ingredients which are soluble with the enhancer composition. This patent does not recognize the deleterious effects on acid-labile drugs of a penetration enhancer such as oleic acid, nor does it suggest the property of functional derivatives of fatty acids to stabilize drugs subject to acid catalyzed degradation, and at the same time function as penetration enhancers.

U.S. Patent No. 5,162,315 describes the use of certain substituted alkanamides as penetration enhancers, but does not suggest their particular suitability in stabilizing acid-labile drugs.

Cooper, E., "Increased Skin Permeability for Lipophilic Molecules" *J. Pharm. Sci.* 73: (Aug. 1984) describes the use of oleic acid in different concentrations in the presence of propylene glycol or 1,1-butanediol, but does not recognize the deleterious effect of the penetration enhancer on acid-labile drugs.

Although penetration enhancers are well-known in the art, problems associated with combining certain penetration enhancers with certain drugs in transdermal compositions have not been addressed. For instance, applicant has observed that oleic acid, which is a commonly used penetration enhancer, will react with certain drugs, not only causing them to degrade but also creating by-products that interfere with drug penetration and delivery. Applicant has discovered that, in order to overcome this type of problem, functional derivatives of fatty acids can be used in transdermal formulations containing drugs that degrade in the presence of weak organic acids such as oleic acid, particularly over prolonged periods of time, for example, for weeks or months during storage. Such drugs are referred to herein as "acid-labile" drugs and include esters,  $\alpha,\beta$ -unsaturated ketones, aminolevulinic acids, amides, imines and similar compounds subject to degradation in the

presence of weak organic acids. Applicant was the first to appreciate the above described problem and solution.

The term "fatty acid" is used here in the broadest sense to include saturated and unsaturated, straight and branched chain aliphatic acids having from four to twenty-four carbon atoms.

The term "functional derivative" is used here to refer to isosteric modifications of fatty acids or to non-acidic derivatives of the carboxylic acid functional group of a fatty acid or isosteric modifications thereof.

#### Summary of the Invention

The present invention relates to a transdermal penetration enhancing composition comprising (a) a therapeutically effective amount of a pharmacologically active drug which is subject to acid catalyzed degradation; (b) a pharmaceutically acceptable carrier substantially free of a lower alkanol; and (c) a penetration enhancing functional derivative of a fatty acid.

In another embodiment, the present invention relates to a method of delivering a pharmacologically active drug comprising topically applying to the skin or mucosal tissues of a mammal a composition comprising (a) a therapeutically effective amount of a pharmacologically active drug which is subject to acid catalyzed degradation; (b) a pharmaceutically acceptable carrier substantially free of a lower alkanol; and (c) a penetration enhancing functional derivative of a fatty acid.

#### Brief Description of the Drawings

FIGURE 1 shows a schematic illustration of an adhesive monolithic device, in accordance with the present invention.

Detailed Description of the Preferred Embodiments

- The present invention provides a penetration enhancing transdermal composition comprising (a) a therapeutically effective amount of a pharmacologically active drug which is subject to acid catalyzed degradation; (b) a pharmaceutically acceptable carrier substantially free of a lower alkanol; and (c) a penetration enhancing functional derivative of a fatty acid.
- By "substantially free of a lower alkanol" is meant less than 5%, and preferably less than 2%, of lower alkanols. For the preferred adhesive carrier, lower alkanols and processing solvents are driven off during processing.
- As discussed above, the term "functional derivative of a fatty acid" means isosteric modifications of fatty acids or non-acidic derivatives of the carboxylic functional group of a fatty acid or isosteric modifications thereof. Specifically, a functional derivative of a fatty acid includes a saturated, or preferably unsaturated (all *cis*), aliphatic acid in which the carboxyl group is substituted with a functional derivative thereof, such as alcohols, polyols, amides, and substituted derivatives thereof, including esters, ethers and N,N' disubstituted amides. The term "fatty acid" as used here and as noted above means higher molecular weight, straight and branched chain saturated and unsaturated aliphatic acids of four to twenty-four carbons, including but not limited to those having an even number of carbon atoms, derived from animals and plants. The expression "functional derivative of a fatty acid" is intended to include at least one functional derivative of a fatty acid.
- As used herein, the term "pharmacologically active drug" and its equivalents, e.g., "agent," "bioactive agent," and "medicament," are intended to have the broadest meaning and includes at least one of any therapeutically, prophylactically and/or

pharmacologically or physiologically beneficial active substance, or mixture thereof, which is delivered to a living organism to produce a desired, usually beneficial, effect.

5 More specifically, any drug which is capable of producing a pharmacological response, localized or systemic, irrespective of whether therapeutic, diagnostic, or prophylactic in nature, particularly in animals, is within the contemplation of the invention.

10 It should be noted that the drugs and/or bioactive agents may be used singularly or as a mixture of two or more such agents, and in amounts sufficient to prevent, cure, diagnose or treat a disease or other condition, as the case may be.

15 However, the drugs for use in this invention are those which are acid-labile, namely those that are degraded by acids, even organic acids, or are degraded in acid catalyzed reactions. The invention is, therefore, particularly suitable for use with  $\alpha$ ,  $\beta$ -unsaturated ketones, especially 3-oxo-4, 5 dehydrosteroids, esters, and  $\alpha$ -ketoamino acids and imines. The acid-labile drug of the present invention may be norethindrone acetate. Other acid-labile drugs which may be included are:

20

ANABOLIC STEROIDS such as Androisoxazole, Bolasterone, Clostebol, Ethylestrenol, Formyldienolone, 4-Hydroxy-19-nortestosterone, Methenolone, Methyltrienolone, Nandrolone, Nandrolone Decanoate, Nandrolone p-Hexyloxyphenyl-propionate, Nandrolone Phenpropionate, Norbolethone, Oxymesterone, Quinbolone, Stenbolone, Trenbolone

25

30

ANDROGENIC STEROIDS such as Boldenone, Fluoxymesterone, Mestanolone, Mesterolone, Methandrostenolone, 17-Methyltestosterone, 17 $\alpha$ -Methyl-testosterone 3-Cyclopentyl Enol Ether, Norethandrolone, Normethandrone, Oxandrolone, Oxymetholone, Prasterone, Stanlolone, Stanozolol, Testosterone, Testosterone 17-Chloral Hemiacetal, Testosterone 17 $\beta$ -Cypionate, Testosterone Enanthate,

35

Testosterone Nicotinate, Testosterone Phenylacetate,  
Testosterone Propionate, Tiomesterone

DIURETIC STEROIDS such as Canrenone, Oleandrin,  
Spironolactone, and

- 5 PROGESTOGENS such as Anagestone, Chlormadinone  
Acetate, Delmadinone Acetate, Demegestone,  
Dimethisterone, Dydrogesterone, Ethinylestrenol,  
Ethisterone, Ethynodiol, Ethynodiol Diacetate,  
Flurogestone Acetate, Gestodene, Gestonorone Caproate,  
10 Haloprogestosterone, 17-Hydroxy-16-methylene--progesterone,  
17 $\alpha$ -Hydroxyprogesterone, 17 $\alpha$ -Hydroxyprogesterone  
Caproate, Medrogestone, Medroxyprogesterone, Megestrol  
Acetate, Melengestrol, Norethindrone, Norethindrone  
Acetate, Norethynodrel, Norgesterone, Norgestimate,  
15 Norgestrel, Norgestrienone, 19-Norprogesterone,  
Norvinisterone, Pentagestrone, Progesterone,  
Promegestone, Quingestronone, Trengestone

- The above list of pharmaceutical agents is based upon  
the list provided in *The Merck Index*, 11th Edition, Merck  
20 & Co. Rahway, N.J. (1989).

- The drugs and mixtures thereof can be present in the  
composition of the present invention in different forms,  
depending on which form yields the optimum delivery  
characteristics. Thus, the drug, containing acidic or  
25 basic groups, respectively, can be in free acid or base  
form, or in the form of salts, esters, or any other  
pharmacologically acceptable functional derivative,  
including components of molecular complexes.

- The amount of drug to be incorporated in the  
30 composition varies depending on the particular drug, the  
desired therapeutic effect, and the time span for which  
the device is to provide therapy. The drug is used in a  
"pharmacologically effective amount." This means that  
the concentration of the drug is such that in the  
35 composition it results in a therapeutic level of drug  
delivered over the term that the transdermal dosage form  
is to be used, preferably with zero order kinetics. Such  
delivery is dependent on many variables including the  
chemical nature of the drug, the form of the drug, the



time period for which the individual dosage unit is to be used, the flux rate of the drug from the system, and a number of other variables. The amount of drug needed can be experimentally determined based on the flux rate of the drug through the system and through the skin when used with and without enhancers. Having determined the flux rate needed, the transdermal delivery system is designed so that the release rate over the period of time of therapeutic use will be at least equal to the flux rate. Of course, the surface area of the transdermal delivery system also affects the delivery of the drug from the system.

In general, therapeutic amounts of drug can be delivered from the composition containing 0.05% to about 50% by weight of drug, or more preferably from about 0.1% to about 30% by weight. However, the composition of this invention is particularly useful for drugs that are used in relatively low concentrations, especially 0.1% to 20% of the total composition.

The carrier of the present invention can be at least one of any pharmaceutically acceptable carrier which is capable of conforming to a surface with which it comes into contact and capable of maintaining the contact so as to facilitate topical application without any adverse physiological response, and which maintain their form and do not appreciably decompose in use. Such carriers can be, among other things, creams, ointments, oils, lubricants and adhesives.

In the preferred embodiment, the carrier is an adhesive or combinations of adhesives such as any of the nontoxic polymers, particularly those known in the art to carry drugs for transdermal delivery, including natural or synthetic elastomers, such as polyisobutylene, styrene, butadiene, styrene isoprene block copolymers, acrylics, urethanes, silicones, styrene butadiene copolymers, acrylic acid polymers, polyacrylates, and polysaccharides such as karaya gum, tragacanth gum, pectin, guar gum, cellulose, and cellulose derivative such as methyl cellulose, propyl cellulose, cellulose

acetate and the like, along with other substances capable of forming a solid colloid that can adhere to the skin or mucosa, alone or in combination with other carriers. The term "adhesive" means a substance, inorganic or organic, natural or synthetic that is capable of surface attachment at the intended application site.

In the most preferred embodiment, the carrier of the present invention is a pressure sensitive adhesive, i.e. a viscoelastic material which adheres instantaneously to most substrates with the application of very slight pressure and remains permanently tacky. Preferably, the pressure sensitive adhesive comprises a blend of at least two polymers and a soluble polyvinylpyrrolidone ("PVP").

The soluble PVP is preferably used in an amount effective to solubilize the drug.

A polymer is a pressure-sensitive adhesive within the meaning of the term as used herein if it has the properties of a pressure-sensitive adhesive per se or functions as a pressure-sensitive adhesive by admixture with tackifiers, plasticizers or other additives. The term pressure-sensitive adhesive also includes mixtures of different polymers and mixtures of polymers, such as polyisobutylenes (PIB) of different molecular weights, the resultant mixtures being a pressure-sensitive adhesive. In the last case, the polymers of lower molecular weight in the mixture are not considered to be "tackifiers," said term being reserved for additives which differ other than in molecular weight from the polymers to which they are added.

As used herein, the term "rubber" refers to a viscoelastic material which has the properties of a pressure-sensitive adhesive and which contains at least one natural or synthetic elastomeric polymer. Suitable rubbers include polysiloxane, polyisobutylene and natural rubber.

The multiple polymer adhesive system is preferably formulated so that it is a pressure-sensitive adhesive at room temperature and has other desirable characteristics for adhesives used in the transdermal drug delivery art.

Such characteristics include good adherence to skin, ability to be peeled or otherwise removed without substantial trauma to the skin, retention of tack with aging, etc. In general, the multiple polymer adhesive system should have a glass transition temperature ( $T_g$ ), measured using a differential scanning calorimeter, of between about  $-70^{\circ}\text{C}$  and  $0^{\circ}\text{C}$ .

The term "acrylic polymer" is used herein as in the art interchangeably with polyacrylate, polyacrylic and acrylic adhesive. The acrylic-based polymer and silicone-based polymer are preferably in a ratio by weight, respectively, from about 2:98 to about 96:4, more preferably from about 2:98 to about 90:10, and even more preferably about 2:98 to about 86:14.

Suitable acrylic adhesives are commercially available and include the polyacrylate adhesives sold under the trademarks Duro-Tak 80-1194, 80-1196, 80-1197, 2287, 2516 and 2852 by National Starch and Chemical Corporation, Bridgewater, New Jersey. Other suitable acrylic adhesives are those sold under the trademarks Gelva-Multipolymer Solution GMS 737, 788, 1151 and 1430 (Monsanto; St. Louis, MO).

The rubber adhesives useful in practicing the invention include hydrocarbon polymers such as natural and synthetic polyisoprene, polybutylene and polyisobutylene, styrene/butadiene polymers, styrene-isoprene-styrene block copolymers, hydrocarbon polymers such as butyl rubber, halogen-containing polymers such as polyacrylo-nitrile, polytetrafluoroethylene, polyvinylchloride, polyvinylidene chloride, and polychloroprene, and polysiloxanes and other copolymers thereof.

Suitable polysiloxanes include silicone pressure-sensitive adhesives which are based on two major components: a polymer, or elastomer, and a tackifying resin. The polysiloxane adhesive is usually prepared by cross-linking the elastomer, typically a high molecular weight polydiorganosiloxane, with the resin, to produce a three-dimensional siloxane structure, via a

condensation reaction in an appropriate organic solvent. The ratio of resin to elastomer is the most important factor which can be adjusted in order to modify the physical properties of polysiloxane adhesives. Sobieski,  
5 et al., "Silicone Pressure Sensitive Adhesives," Handbook of Pressure-Sensitive Adhesive Technology, 2nd ed., pp. 508-517 (D. Satas, ed.), Van Nostrand Reinhold, New York (1989).

Suitable silicone pressure-sensitive adhesives are  
10 commercially available and include the silicone adhesives sold under the trademarks BIO-PSA X7-3027, X7-4203, Q7-4503, X7-4603, X7-4301, X74303, X7-4919, X7-2685, and X7-3122 by Dow Corning Corporation, Medical Products, Midland, Michigan. BIO-PSA X7-4203, X7-4301 and X7-4303  
15 are particularly suitable for use in formulations containing amine-functional drugs, such as albuterol.

In the practice of preferred embodiments of the invention, the polysiloxane constitutes preferably from about 9% to about 97% of the total weight of the  
20 pressure-sensitive adhesive composition, more preferably about 12% to about 97%, and optimally about 14% to about 94%.

The composition of the present invention may also include a drug solubilizing amount of a solvent. A "drug  
25 solubilizing effective amount of a solvent" refers to non-toxic, pharmaceutically acceptable substances, preferably liquids which do not substantially negatively affect the adhesion properties of the system and in which the drugs in the amounts employed are fully soluble. For  
30 instance, the solvent may be primarily a polyhydric alcohol or combination of polyhydric alcohols, particularly if the carrier is a gum. The term polyhydric alcohol means any organic polyol. Polyhydric alcohols include glycols, triols and polyols having 4 to  
35 6 alcoholic hydroxyl groups.

In a preferred embodiment, the carrier is a pressure sensitive adhesive comprising a blend of polymers including PVP. Indeed, soluble PVP has been found to be highly effective in solubilization of drugs in adhesive-

type transdermal drug delivery systems according to the invention, wherein the carrier is a blend of polymers. In particular, soluble PVP has proved useful in maintaining a norethindrone acetate (NETA) system and an  
5 NETA/estradiol system substantially crystal-free. Other specific drugs for which soluble PVP is particularly usefully employed according to the invention include albuterol, estradiol, haloperidol and alprazolam.

The amount and type of soluble PVP required in the  
10 foregoing preferred embodiment will depend on the quantity and type of drug present in the adhesive, as well as the type of adhesive.

However, for drug molecules which are not readily soluble in the polymer system containing PVP, another  
15 solvent or "co-solvent" for the drug and polymer can be added. Co-solvents, such as lecithin, retinol derivatives, tocopherol, dipropylene glycol, triacetin, propylene glycol, saturated and unsaturated fatty acids, mineral oil, silicone fluid, alcohols, butyl benzyl  
20 phthalate, and the like are useful in the practice of the instant invention depending on the solubility of the drug in the multiple polymer adhesive system.

In a preferred embodiment of the invention, a transdermal drug delivery system is prepared by mixing a  
25 soluble PVP, polyacrylate, polysiloxane, drug, co-solvent(s), and tackifying agent, if needed, in an appropriate volatile solvent(s), then casting the mixture and removing the solvent(s) by evaporation to form a film.

30 Suitable volatile solvents include, but are not limited to, alcohols such as isopropanol and ethanol; aromatics such as xylenes and toluene; aliphatics such as hexane, cyclohexane, and heptane; and alkanolic acid esters such as ethyl acetate and butyl acetate.

35 A "penetration enhancer" is an agent known to accelerate the delivery the drug through the skin. These agents also have been referred to as accelerants, adjuvants, and sorption promoters, and are collectively referred to herein as "enhancers." This

class of agents includes those with diverse mechanisms of action including those which have the function of improving the solubility and diffusibility of the drug within the multiple polymer and those which improve percutaneous absorption, for example, by changing the ability of the stratum corneum to retain moisture, softening the skin, improving the skin's permeability, acting as penetration assistants or hair-follicle openers or changing the state of the skin including the boundary layer.

According to the present invention, a "penetration enhancing amount" is an amount up to about 20% by weight of the whole composition, but preferably an amount of about 1% to about 10% by weight.

The penetration enhancer of the present invention is, as discussed above, a functional derivative of a fatty acid, which includes isosteric modifications of fatty acids or non-acidic derivatives of the carboxylic functional group of a fatty acid or isosteric modifications thereof. Preferably, the functional derivative of a fatty acid is an unsaturated (all *cis*) alkanolic acid in which the carboxyl group is substituted with a functional derivative thereof, such as alcohols, polyols, amides and substituted derivatives thereof, including esters, ethers and N,N' disubstituted amides. The term "fatty acid" means a fatty acid that has four to twenty-four carbon atoms, and includes but is not limited to those derived from animals and plants. Particular preferred derivatives are those based on oleic acid, e.g., oleyl alcohol, and oleamide as follows:

Group	Formulation	CFTA Name
ALCOHOLS	$\text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_6)\text{OH}$	Oleyl Alcohol 1
	$\text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2(\text{OCH}_2\text{CH}_2)_2\text{OH}$	Oleith-2
	$\text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2(\text{OCH}_2\text{CH}_2)_5\text{OH}$	Oleith-5
	$\text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2(\text{OCH}_2\text{CH}_2)_{10}\text{OH}$	Oleith-10
	$\text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2(\text{OCH}_2\text{CH}_2)_{20}\text{OH}$	Oleith-20
	$\text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2(\text{OCH}_2\text{CH}_2)_{30}\text{OH}$	Oleith-30
	$\begin{array}{c} \text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2(\text{OCH}-\text{CH}_2)_{10}\text{OH} \\   \\ \text{CH}_3 \end{array}$	PPG-10 Oleyl Ether
	$\begin{array}{c} \text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2(\text{OCH}-\text{CH}_2)_{20}\text{OH} \\   \\ \text{CH}_3 \end{array}$	PPG-20 Oleyl Ether
	$\begin{array}{c} \text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2(\text{OCH}-\text{CH}_2)_{30}\text{OH} \\   \\ \text{CH}_3 \end{array}$	PPG-50 Oleyl Ether
ESTERS	$\begin{array}{c} \text{O} \\   \\ \text{CH}_3(\text{CH}_2)_7(\text{CH}=\text{CH}(\text{CH}_2)_7\text{C}-\text{OCH}_2\text{CH}_2\text{OH} \\   \\ \text{CH}_2\text{OH} \end{array}$	Glyceryl Oleate
AMIDES	$\begin{array}{c} \text{O} \\   \\ \text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{C}-\text{NH}_2 \end{array}$	Oleamide
	$\begin{array}{c} \text{O} \\   \\ \text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{C}-\text{N}(\text{CH}_2\text{CH}_2\text{OH})_2 \end{array}$	Oleamide DEA
	$\begin{array}{c} \text{O} \\   \\ \text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{C}-\text{NH}-\text{CH}_2\text{CH}_2\text{OH} \end{array}$	Oleamide MEA
	$\begin{array}{c} \text{O} \\   \\ \text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{C}-\text{NH}-\text{CH}_2\text{CH}_2\text{OH} \\   \\ \text{CH}_3 \end{array}$	Oleamide MIPA
Zwitterion	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}-\text{N}-\text{CH}_2\text{COO} \\   \\ \text{CH}_3 \end{array}$	Oleyl Betamine

In the preferred embodiment of the present invention, wherein the carrier is a pressure sensitive adhesive comprising a blend of polymers, an exemplary general method of preparation is as follows:

- 5           1.   Appropriate amounts of soluble PVP, solvent(s), functional derivative of a fatty acid enhancer(s), and organic solvent(s) (for example, toluene) are combined and thoroughly mixed in a vessel.
- 10           2.   The drug is then added to the mixture and agitation is carried out until the drug is uniformly mixed in.
3.   Appropriate amounts of polysiloxane and polyacrylate are then added to the drug mixture, and thoroughly mixed.
- 15           4.   The formulation is then transferred to a coating operation where it is coated onto a protective release liner at a controlled specified thickness. The coated product is then passed through an oven in order to drive off all volatile processing solvents.
- 20           5.   The dried product on the release liner is then joined to the backing material and wound into rolls for storage.
6.   Appropriate size and shape "systems" are die-cut from the roll material and then pouched.
- 25           The order of steps, the amount of the ingredients, and the amount and time of agitation or mixing may be important process variables which will depend on the specific polymers, drug, cosolvents, and enhancers used in the formulation. These factors can be adjusted by
- 30           those skilled in the art, while keeping in mind the object of providing a uniform product. It is believed that a number of other methods, including changing some of the order of steps, can be carried out and will give desirable results. In addition to having various shapes,
- 35           the dosage units produces may come in various sizes. A surface area in the range of 1 to 200 square centimeters is contemplated, and the presently preferred sizes are: 5, 10, 15, 20, 30, 30 and 60 square centimeters.



To summarize, the preferred and optimum compositions for rubber and polyacrylate embodiments are as follows:

TABLE I  
PERCENT BY WEIGHT

5	Component	Preferred Range	Optimum Range
	Rubber	97 - 9	94 - 14
	Polyacrylate	0 - 95	5 - 85
	PVP	0 - 20	5 - 15
10	Co-solvent (s)	0 - 30	0 - 20
	Fatty acid derivative enhancer	1 - 20	5 - 15
	Drug (s)	0.05 - 50	0.1 - 20

15 In certain embodiments of the invention a plasticizer or tackifying agent is incorporated into the formulation to improve the adhesive characteristics of the pressure-sensitive adhesive composition.

20 The compositions of this invention may further be provided with various thickeners, fillers and other additives known for use with transdermal drug delivery systems. Where the composition tends to absorb water, for example, when lecithin is used as a co-solvent, hydrophilic substances are especially useful.

25 In a device aspect of the invention, the pressure-sensitive adhesive composition can be used as an adhesive portion of any transdermal drug delivery system (e.g., a reservoir device) or it can comprise an adhesive monolithic device. Of course, the principles of the invention would still apply to embodiments where the transdermal drug delivery composition is not a pressure-sensitive adhesive and comprises a drug reservoir.

30 Reference to FIG. 1 shows a schematic illustration of an adhesive monolithic device embodiment of the invention 10. The transdermal drug delivery system comprises a monolithic body 11 of a defined geometric shape with a protective release liner 12 on one side of

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monolithic body 11 and a backing layer 13 on the other side. Removal of the release liner 12 exposes the pressure-sensitive multiple polymer adhesive composition which functions as the drug carrier matrix, a drug penetration enhancer and as the means of applying the system to the patient.

A device, or individual dosage unit, of the present invention can be produced in any manner known to those of skill in the art. After the dermal composition is formed, it may be brought into contact with the backing layer in any manner known to those of skill in the art. Such techniques include calendar coating, hot melt coating, solution coating, etc. Of course, backing materials are well known in the art and can comprise plastic films of polyethylene, vinyl acetate resins, polyester, polypropylene, BAREX®, ethylene/vinyl acetate copolymers, polyvinyl chloride, polyurethane, and the like, metal foils, non-woven fabric, cloth, coextrusions or laminations of the above and commercially available laminates. The backing material generally has a thickness in the range of 2 to 1000 micrometers and the dermal composition is generally disposed on backing material in a thickness ranging from about 12 to 250 micrometers thick.

Suitable release liners are also well known in the art.

The configuration of the transdermal delivery system of the present invention can be in any shape or size as is necessary or desirable. Illustratively, a single dosage unit may have a surface area in the range of 1 to 200 cm<sup>2</sup>. Preferred sizes are from 5 to 60 cm<sup>2</sup>.

In yet another embodiment, the present invention relates to a method of enhancing the penetration of a pharmacologically active drug in a transdermal composition comprising topically applying to a mammal a transdermal composition comprising (a) a therapeutically effective amount of a pharmacologically active drug; (b) a pharmaceutically acceptable carrier; and

(c) a penetration enhancing, drug acid-lability reducing effective amount of a functional derivative of a fatty acid.

"Enhancing penetration" refers to the acceleration of a drug through the skin or mucosa. "Topical application" means the administration of the composition of the invention to a mammal in any way which results in the physical contact of the composition with skin or mucosa at an anatomical site of interest. Those of skill in the art would know what dosages and length of use to prescribe for a given formulation, depending upon the desired therapeutic result, the type of drug and other components in the transdermal composition, the size of the transdermal composition in its final form and the age and physical state of the mammal.

The following specific examples are included as illustrative of pressure-sensitive adhesive compositions and transdermal drug delivery systems, and methods of making same, within the contemplation of the invention. These examples are in no way intended to be limiting of the scope of the invention.

#### EXAMPLE 1

COMPONENT	PERCENT BY WEIGHT
Polysiloxane A Adhesive (BIO-PSA Q7-4503)	5.0
Polysiloxane B Adhesive (BIO-PSA X7-4603)	71.6
Polyacrylate Adhesive (GMS 737)	5.0
Oleamide	6.0
Dipropylene Glycol	2.0
Polyvinylpyrrolidone (Kollidon 30)	5.0

	Polyoxyethylene (2) Oleyl Ether (Brij 93)	2.0
	Norethindrone Acetate	3.0
5	Estradiol	<u>0.4</u>
		<hr/> 100.0 <hr/>

## EXAMPLE 2

		COMPONENT	PERCENT BY WEIGHT
5		Polysiloxane A Adhesive (BIO-PSA Q7-4503)	5.0
		Polysiloxane B Adhesive (BIO-PSA X7-4603)	71.6
		Polyacrylate Adhesive (GMS 737)	5.0
		Oleamide	6.0
		Dipropylene Glycol	4.0
10		Polyvinylpyrrolidone (Kollidon 30)	5.0
		Norethindrone Acetate	3.0
		Estradiol	<u>0.4</u>
			100.0

## EXAMPLE 3

An estradiol/norethindrone acetate-polymer mixture is prepared by combining 0.8 parts of estradiol, 3.0 parts of norethindrone acetate, 4.0 parts of polyoxyethylene (2) oleyl ether (Brij 93), 6.0 parts of oleyl alcohol, 10.0 parts of polyvinylpyrrolidone (Kollidon VA 64), 5.0 parts of polyacrylate adhesive (GMS 737), and 71.2 parts of polysiloxane adhesive (BIO-PSA X7-4603) in an appropriate container, and mixing well until the mixture is completely homogeneous. The resulting composition has the ingredient concentrations on a "dry" basis, that is, after removal of volatile process solvents, given below.

	COMPONENT	PERCENT BY WEIGHT
15	Polysiloxane adhesive (BIO-PSA X7-4603)	71.2
	Polyacrylate adhesive (GMS 737)	5.0
	Oleyl Alcohol	6.0
20	Polyoxyethylene (2) Oleyl Ether (Brij 93)	4.0
	Polyvinylpyrrolidone (Kollidon 30)	10.0
	Norethindrone Acetate	3.0
25	Estradiol	0.8
		100.0

Although the invention has been described in terms of specific embodiments and applications, persons skilled in the art can, in light of this teaching, generate additional embodiments without exceeding the scope or departing from the spirit of the claimed invention. Accordingly, it is to be understood that the drawing and description in this disclosure are proffered to facilitate comprehension of the invention, and should not be construed to limit the scope thereof.

What Is Claimed Is:

1. A transdermal drug penetration enhancing composition comprising (a) a therapeutically effective amount of a pharmacologically active, acid-labile drug  
5 that is subject to acid catalyzed degradation; (b) a pharmaceutically acceptable carrier substantially free of a lower alkanol; and (c) a penetration-enhancing amount of a functional derivative of a fatty acid.
2. The composition of claim 1, wherein said  
10 functional derivative of a fatty acid is selected from the group consisting of an amide, an alcohol, a polyol, an ether and an ester.
3. The composition of claim 2, wherein said functional derivative is oleamide or oleyl alcohol.
4. The composition of any one of claims 1-3,  
15 wherein said acid-labile drug is an  $\alpha,\beta$ -unsaturated ketosteroid, a 5-dehydrosteroid, an  $\alpha$ -ketoamino acid, a carboxylic acid ester, or an imine.
5. The composition of claim 4, wherein said drug  
20 is norethindrone acetate.
6. The composition of claim 4, wherein said adhesive comprises a blend of at least two polymers and a soluble polyvinylpyrrolidone.
7. The composition of any one of claims 1-6, which  
25 further comprises a solvent.
8. The composition of claim 7, wherein said carrier is a polyacrylate adhesive, said acid-labile drug is norethindrone acetate; said penetration enhancer is selected from the group consisting of oleyl alcohol and  
30 oleamide; and said solvent is a glycol.

9. The composition of claim 7, comprising: about 3% by weight of the total composition of norethindrone acetate; about 0.4 percent by weight of the total composition of estradiol; about 5.0 percent by weight of the total composition of polysiloxane A adhesive; about 71.6 percent by weight of the total composition of polysiloxane B adhesive; about 5.0 percent by weight of the total composition of polyacrylate adhesive; about 6.0 percent by weight of the total composition of oleamide; about 2.0 percent by weight of the total composition of dipropylene glycol; about 5.0 percent by weight of the total composition of polyvinylpyrrolidone; and about 2.0 percent by weight of the total composition of polyoxyethylene (2) oleyl ether.

10. The composition of claim 7, comprising: about 3% by weight of the total composition of norethindrone acetate; about 0.4 percent by weight of the total composition of estradiol; about 5.0 percent by weight of the total composition of polysiloxane A adhesive; about 71.6 percent by weight of the total composition of polysiloxane B adhesive; about 5.0 percent by weight of the total composition of polyacrylate adhesive; about 6.0 percent by weight of the total composition of oleamide; about 4.0 percent by weight of the total composition of dipropylene glycol; and about 5.0 percent by weight of the total composition of polyvinylpyrrolidone.

11. The composition of claim 7, comprising: about 3% by weight of the total composition of norethindrone acetate; about 0.8 percent by weight of the total composition of estradiol; about 71.2 percent by weight of the total composition of polysiloxane A adhesive; about 5.0 percent by weight of the total composition of polyacrylate adhesive; about 6.0 percent by weight of the total composition of oleyl alcohol; about 4.0 percent by weight of the total composition of polyoxyethylene (2) oleyl ether; and about 10.0 percent by weight of the total composition of polyvinylpyrrolidone.



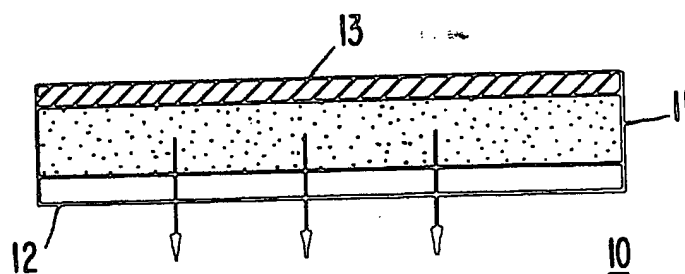
12. A method of enhancing the penetration of a pharmacologically active acid-labile drug, comprising the step of topically applying to a mammal a composition comprising:

5 (a) a therapeutically effective amount of a pharmacologically active drug which is subject to acid catalyzed degradation;

(b) a pharmaceutically acceptable carrier substantially free of a lower alkanol; and

10 (c) a penetration-enhancing amount of a functional derivative of a fatty acid.

FIG. 1



## INTERNATIONAL SEARCH REPORT

Int'l Application No

PCT/US 96/00015

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 A61K9/70 A61K47/10 A61K47/18

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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P, X, L	WO, A, 95 18603 (NOVEN PHARMACEUTICALS, INC.) 13 July 1995 THE PRIORITY CLAIM OF THE PRESENT APPLICATION MIGHT NOT BE JUSTIFIED. see page 54 - page 56; examples 31-33 ---	1-12
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X	EP, A, 0 573 133 (SCHERING AKTIENGESELLSCHAFT) 8 December 1993 see page 6; example 3 see page 7; example 5 --- -/-	1, 2, 4, 7, 12

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

30 May 1996

Date of mailing of the international search report

06.06.96

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## INTERNATIONAL SEARCH REPORT

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